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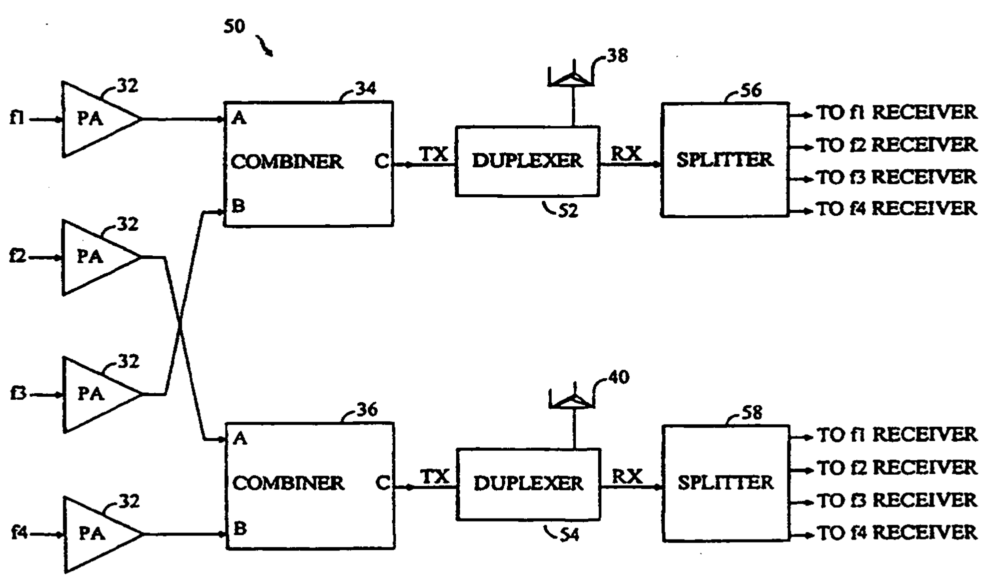

(57) Abstract

Prior to transmission from the base station, a signal combining method for a CDMA system combines individual frequency channels (f1, f2, f3, f4) into sets of frequency channels such that no two frequency channels in any one set are adjacent in frequency. A dual diversity reception and transmit signal combining system includes two or more signal combiners (34, 36) each coupled to a respective set of frequency channels in which no two frequency channels are adjacent. Two or more duplexors (62, 64) are each coupled to a respective signal combiner. An antenna (38) is connected to each duplexor (62, 64), and two or more splitters (56, 58) are each coupled to a respective duplexor. The respective signal combiners and duplexors can be integrated into single devices.

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SIGNAL COMBINING METHOD IN A BASE STATION OF A CDMA SYSTEM

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention pertains generally to the field of wireless communications, and more particularly to signal combining in a multichannel CDMA communication system.

II. Background

The field of wireless communications has many applications including, e.g., cordless telephones, paging, wireless local loops, and satellite communication systems. A particularly important application is cellular telephone systems for mobile subscribers. (As used herein, the term "cellular" systems encompasses both cellular and PCS frequencies.) Various over-the-air interfaces have been developed for such cellular telephone systems including, e.g., frequency division multiple access (FDMA), time division multiple access (TDMA), and code division multiple access (CDMA). In connection therewith, various domestic and international standards have been established including, e.g., Advanced Mobile Phone Service (AMPS), Global System for Mobile (GSM), and Interim Standard 95 (IS-95). In particular, IS-95 and its derivatives, IS-95A, ANSI J-STD-008, etc. (referred to collectively herein as IS-95), are promulgated by the Telecommunication Industry Association (TIA) and other well known standards bodies.

Cellular telephone systems configured in accordance with the use of the IS-95 standard employ CDMA signal processing techniques to provide highly efficient and robust cellular telephone service. An exemplary cellular telephone system configured substantially in accordance with the use of the IS-95 standard is described in U.S. Patent No. 5,103,459, which is assigned to the assignee of the present invention and fully incorporated herein by reference. The aforesaid patent illustrates transmit, or forward-link, signal processing in a CDMA base station. Exemplary receive, or reverse-link, signal processing in a CDMA base station is described in U.S. Application Serial No. 08/987,172, filed December 9, 1997, entitled MULTICHANNEL DEMODULATOR, which is assigned to the assignee of the present invention and fully incorporated herein by reference. In CDMA systems, power control is a critical issue. An exemplary method of power control in a

CDMA system is described in U.S. Patent No. 5,056,109, which is assigned to the assignee of the present invention and fully incorporated herein by reference.

A primary benefit of using a CDMA over-the-air interface is that comunications are conducted over the same RF band. For example, each mobile subscriber unit (typically a cellular telephone) in a given cellular telephone system can communicate with the same base station by transmitting a reverse link signal over the same 1.25 MHz of RF spectrum. Similarly, each base station in such a system can communicate with mobile units by transmitting a forward link signal over another 1.25 MHz of RF spectrum.

Transmitting signals over the same RF spectrum provides various benefits including, e.g., an increase in the frequency reuse of a cellular telephone system and the ability to conduct soft handoff between two or more base stations. Increased frequency reuse allows a greater number of calls to be conducted over a given amount of spectrum. Soft handoff is a robust method of transitioning a mobile unit from the coverage area of two or more base stations that involves simultaneously interfacing with two base stations. (In contrast, hard handoff involves terminating the interface with a first base station before establishing the interface with a second base station.) An exemplary method of performing soft handoff is described in U.S. Patent No. 5,267,261, which is assigned to the assignee of the present invention and fully incorporated herein by reference.

In CDMA systems that operate according to the IS-95 standard, each sector of each base station transmits, or radiates, one or more spread spectrum signals, each occupying a distinct frequency range, or channel, each of which is modulated by a pseudorandom noise (PN) spreading sequence at the rate of 1.2288 Mchips per second, producing a signal approximately 1.25 MHz wide. When a given sector of a base station must radiate more than one such signal, the signals must somehow be combined. When such combining is performed after the power amplifier stage, the combiner must provide isolation to protect each power amplifier from the signals produced by the other power amplifiers. Failure to provide such isolation could result in the generation of undesired intermodulation products. Alternatively, amplifier failure could result. It is to be understood, of course, that such transmit signal combining is not unique to CDMA cellular systems. Other cellular standards, such as AMPS, GSM, etc., also transmit multiple frequency channel signals from each sector of a base station, and therefore

make use of signal combining. However, combining is simplified due to the sparse cellular frequency reuse associated with such systems.

Conventionally, signal combining has been accomplished via a number of methods. In one such method, called space combining, the output from each power amplifier is directed to a separate antenna. There is enough isolation between the antennas that each power amplifier is protected from the output signals of other amplifiers. The antennas are pointed in generally the same direction, as they are intended to cover the same geographical area, and must be placed far enough apart to provide the desired signal isolation. Understandably, this method becomes cumbersome when the number of signals to be combined is large.

An alternative conventional method of signal combining within a sector is to use a frequency-selective signal combiner. For example, output power from two power amplifiers is combined by a frequency-selective signal combiner and the combined signal is sent to a single antenna. The signal combiner must allow both of its input signals to reach its output port while preventing either input signal from reaching the input port of the other input signal. This task is typically accomplished via a pair of frequency-selective filters inside the combiner. It is understood by those of skill in the art, however, that a frequency-selective combiner may be designed with a wide variety of alternative internal circuit topologies. It is also known in the art to provide an isolator device to the frequency-selective filters in accomplishing the above-described task. Typically, the amount of isolation that a combiner must achieve is specified by a number of decibels (dB) that a signal input to one port is attenuated by when it appears at the other input port.

If the two signal frequencies are far enough apart, such as in an AMPS system, for example, a frequency-selective combiner can be readily designed. By way of example, in the AMPS system, it is usual that each cell trasmits on one-seventh of the frequency channels available for the whole system. Each sector of a three-sectored cell would transmit on one-third of these frequencies, i.e., on 1/21st of the total. Hence, an AMPS cell design can take advantage of this sparse frequency reuse to facilitate implementation of a frequency-selective signal combiner. For example, to combine two frequency channels in an AMPS system (each channel is 30kHz wide in such a system), the spacing between the center frequencies of the channels is 21 x 30 kHz, or 630 kHz. Each of the two filters inside the combiner must pass a channel that is 30 kHz wide (the passband) while suppressing another channel, also 30 kHz wide (the stopband), by at least 20 dB. The transition band between

the passband and the stopband is large relative to the widths of the passband and the stopband, which renders frequency-selective filters relatively simple to implement in an AMPS system.

However, in a CDMA system operating according to the IS-95 standard, every frequency channel may be used in every sector of every cell. Therefore, the requisite large spacing between frequency channels that must be combined is not present. In a CDMA cell, it is often necessary to combine signals in two or more directly adjacent frequency channels. For these reasons, a frequency-selective signal combiner for a CDMA cellular telephone system is difficult to design and manufacture. Thus, there is a need for an efficient, frequency-selective method of combining CDMA carrier signals in a cellular base station.

SUMMARY OF THE INVENTION

The present invention is directed to an efficient, frequency-selective method of combining CDMA carrier signals in a cellular base station. Accordingly, a signal combining method includes the steps of combining individual frequency channels into sets of frequency channels such that no two individual frequency channels in any one set are adjacent in frequency, and transmitting the sets of frequency channels. Preferably, one or more of the frequency channels transmitted is a spread spectrum signal. Advantageously, one or more of the frequency channels transmitted is a signal that complies with the TIA IS-95A standard or the ANSI J-STD-008 standard.

In a first aspect of the invention, a transmit signal combining system advantageously includes two or more antennas and two or more signal combiners. Each signal combiner is connected to a respective antenna and is coupled to a respective set of frequency channels, the sets of frequency channels being selected such that no two frequency channels in any one set are adjacent in frequency.

In a second, separate aspect of the invention, a dual diversity reception and transmit signal combining system advantageously includes two or more signal combiners each coupled to a different set of frequency channels wherein no two frequency channels in any one set are adjacent in frequency, and two or more duplexors each coupled to a respective signal combiner. An antenna is connected to each duplexor, and two or more splitters are each coupled to a respective duplexor.

In a third, separate aspect of the invention, a dual diversity reception and transmit signal combining system advantageously includes two or more integrated duplexor/combiners each coupled to a different set of frequency channels wherein no two frequency channels in any one set are adjacent in frequency. An antenna is connected to each integrated duplexor/combiner, and two or more splitters are each coupled to a respective integrated duplexor/combiner.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a cellular telephone system.

FIG. 2 is a block diagram of a transmit signal combining system that can be used in a sector of a base station in the cellular telephone system of FIG. 1.

FIG. 3 is a graph of a pair of adjacent frequency channels sent to a frequency-selective signal combiner and the response requirements for a pair of filters within the frequency-selective signal combiner that process the respective frequency channels.

FIG. 4 is a graph of a pair of nonadjacent frequency channels sent to a frequency-selective signal combiner and the response requirements for a pair of filters within the frequency-selective signal combiner that process the respective frequency channels.

FIG. 5 is a block diagram of a dual diversity reception and transmit signal combining system that can be used in a sector of a base station in the cellular telephone system of FIG. 1.

FIG. 6 is a block diagram of a dual diversity reception and transmit signal combining system that employs integrated duplexor/combiners and can be used in a sector of a base station in the cellular telephone system of FIG. 1.

FIG. 7 is a graph of overlapping frequency channels whose individual bandwidths are greater than the spacing between them.

FIG. 8 is a graph of overlapping frequency channels of differing bandwidths.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As illustrated in FIG. 1, a CDMA wireless telephone system generally includes a plurality of mobile subscriber units 10, a plurality of base stations 12, a base station controller (BSC) 14, and a mobile switching center (MSC) 16. The MSC 16 is configured to interface with a conventional public switch telephone network (PSTN) 18. The MSC 16 is also configured to interface with the BSC 14. The BSC 14 is coupled to each base station 12. The base stations 12 may also be known as base station transceiver subsystems (BTSs) 12. Alternatively, "base station" may be used in the industry to refer collectively to a BSC 14 and one or more BTSs 12, which BTSs 12 may also be denoted "cell sites" 12. (Alternatively, sectors of a given BTS 12 may be referred to as cell sites.) The mobile subsriber units 10 are typically cellular telephones 10, and the cellular telephone system is advantageously a CDMA system configured for use in accordance with the IS-95 standard.

During typical operation of the cellular telephone system, the base stations 12 receive sets of reverse link signals from sets of mobile units 10. The mobile units 10 are conducting telephone calls or other communications. Each reverse link signal received by a given base station 12 is processed within that base station 12. The resulting data is forwarded to the BSC 14. The BSC 14 provides call resource allocation and mobility management functionality including the orchestration of soft handoffs between base stations 12. The BSC 14 also routes the received data to the MSC 16, which provides additional routing services for interface with the PSTN 18. Similarly, the PSTN 18 interfaces with the MSC 16, and the MSC 16 interfaces with the BSC 14, which in turn controls the base stations 12 to transmit sets of forward link signals to sets of mobile units 10.

In the CDMA system of FIG. 1, each base station 12 includes at least one sector (not shown), each sector comprising an antenna pointed in a particular direction radially away from the base station 12. Preferably, each base station 12 includes three sectors, and the radial directions each sector antenna points differ by 120 degrees.

In a particular embodiment, as depicted in FIG. 2, a transmit signal combining system 30 is used to combine a plurality of signals transmitted by a given sector of a base station while protecting each power amplifier 32 from the signals produced by the remaining power amplifiers 32. Advantageously, the transmit signal combining system 30 uses a combination of space combining and frequency-selective signal combining.

The transmit signal combining system 30 advantageously includes four frequency channels having center frequencies f1, f2, f3, and f4. The four frequency channels are coupled to a transmit signal processing path of the base station (not shown). Transmit signal processing in an exemplary CDMA base station is described in U.S. Patent No. 5,103,459, which is assigned to the assignee of the present invention and fully incorporated herein by reference. It is to be understood by those of skill in the art that any reasonable number of frequency channels could be used. Each frequency channel is input to a particular power amplifier 32, there being four power amplifiers 32 in the embodiment shown. The power amplifier 32 coupled to the f1 frequency channel is configured to send an output signal to a first input port A of a first frequency-selective signal combiner 34. The power amplifier 32 coupled to the f2 frequency channel is configured to send an output signal to a first input port A of a second frequency-selective signal combiner 36. The power amplifier 32 coupled to the f3 frequency channel is configured to send an output signal to a second input port B of the first frequency-selective signal combiner 34. The power amplifier 32 coupled to the f4 frequency channel is configured to send an output signal to a second input port B of the second frequency-selective signal combiner 36. The first frequency-selective signal combiner 34 is configured to send a signal from an output port C to a first antenna 38. The second frequency-selective signal combiner 36 is configured to send a signal from an output port C to a second antenna 40. It is to be understood by those of skill in the art that while in the embodiment depicted there are two antennas in a sector of an exemplary CDMA base station, there could be any number of antennas in such a sector.

The power amplifiers 32 and the frequency-selective signal combiners 34, 36 are conventional components as understood by those of skill in the art, and are available off the shelf. Each frequency-selective signal combiner 34, 36 advantageously includes two filters to process the respective two received frequency channels, as understood by those of skill in the art. It is also to be understood, however, that the frequency-selective signal combiners 34, 36 could be designed with any reasonable number of filters (to process any reasonable number of frequency channels, depending upon the particular type of CDMA base station sector), as known in the art.

In operation the spacing between the frequency channels f1, f2, f3, and f4 is advantageously 1.25 MHz. It is to be understood, however, that any reasonable spacing may be used. The odd-numbered frequency channels f1 and f3 are combined using frequency-selective signal combining and then fed to the first antenna 38. Similarly, the even-numbered frequency

channels f2 and f4 are combined using frequency-selective signal combining and then fed to the second antenna 40. In this way, nonadjacent frequency channels are grouped together on one antenna, thereby reducing the performance requirements on the frequency-selective combiners 38, 40, which can therefore be manufactured at lower cost.

As used herein with respect to any pair of frequency channels, the terms "nonadjacent" or "not . . . adjacent" are intended to mean that the bandwidths of the two frequency channels are separated by at least one frequency channel width. Thus, two neighboring frequency channels are considered to be nonadjacent if the spacing between the high band edge of the first frequency channel and the low band edge of the second frequency channel is greater than or equal to the minimum bandwidth allocated to a frequency channel in the CDMA system. If, on the other hand, the high band edge of the first frequency channel is displaced away from the low band edge of the second frequency channel by a spectrum distance of less than the minimum bandwidth allocated to a frequency channel in the CDMA system, the first and second neighboring frequency channels are considered to be adjacent.

As shown in FIG. 3, a pair of frequency channels is considered adjacent if the bandwidths of the two channels are shoulder to shoulder. If two adjacent frequency channels in a CDMA system were sent after the power amplifier stage to the same frequency-selective signal combiner, as known in the art, the required responses for the filters within the signal combiner would have to approach the response for an ideal filter, as illustrated in FIG. 3.

As shown in FIG. 4, a pair of nonadjacent frequency channels have bandwidths that are not shoulder to shoulder. In the graph of FIG. 4, an even-numbered frequency channel is interposed between the pair of odd-numbered frequency channels, in keeping with the embodiment shown in FIG. 2. As can be seen from FIG. 4, the required responses for the filters within the frequency-selective signal combiner need not approach those of an ideal filter. In the embodiment shown, the 1.25-MHz-wide transition band between the passband and stopband of each filter allows the filters to be constructed under less rigid performance constraints.

Preferably, the embodiment shown in FIG. 2 is repeated in each sector of each CDMA base station in the system of FIG. 1. Alternative embodiments having differing numbers of frequency channels and/or antennas within a sector may be employed.

It is known in the art of cellular telephone systems to use two or more antennas in each sector. This allows two antennas to be used for reception (commonly called diversity reception), which provides an improved resistance to signal fading. In a specific embodiment, a pair of antennas is used for both diversity reception and transmit signal combining, as shown in FIG. 5.

In the embodiment depicted in FIG. 5, a dual diversity reception and transmit signal combining system 50 advantageously includes four frequency channels having center frequencies f1, f2, f3, and f4. The frequency channels are coupled to a transmit signal processing path of the base station, as described in connection with the embodiment of FIG. 2. It is to be understood by those of skill in the art that any reasonable number of frequency channels could be used. Each frequency channel is input to a particular power amplifier 32, there being four power amplifiers 32 in the embodiment shown. The power amplifier 32 coupled to the f1 frequency channel is configured to send an output signal to a first input port A of a first frequency-selective signal combiner 34. The power amplifier 32 coupled to the f2 frequency channel is configured to send an output signal to a first input port A of a second frequency-selective signal combiner 36. The power amplifier 32 coupled to the f3 frequency channel is configured to send an output signal to a second input port B of the first frequency-selective signal combiner 34. The power amplifier 32 coupled to the f4 frequency channel is configured to send an output signal to a second input port B of the second frequency-selective signal combiner 36. The first frequency-selective signal combiner 34 is configured to send a signal from an output port C to a transmit input port of a first frequency-selective duplexor 52. The first duplexor 52 is connected to a first antenna 38. The second frequency-selective signal combiner 36 is configured to send a signal from an output port C to a transmit input port of a second frequency-selective duplexor 54. The second duplexor 54 is connected to a second antenna 40. It is to be understood by those of skill in the art that while in the embodiment depicted there are two antennas in a sector of an exemplary CDMA base station, there could be any number of antennas in such a sector. The first duplexor 52 is configured to send a signal from a receive output port to a first splitter 56, which is advantageously configured to send four output signals to, respectively, four receivers (not shown) for the four frequency channels f1, f2, f3, and f4. The second duplexor 54 is configured to send a signal from a receive output port to a second splitter 58, which is

advantageously configured to send four output signals to, respectively, the four receivers for the four frequency channels f1, f2, f3, and f4.

As described with respect to the embodiment of FIG. 2, the power amplifiers 32 and the frequency-selective signal combiners 34, 36 are preferably conventional components. The duplexors 52, 54 and the splitters 56, 58 are also advantageously conventionally known components.

In operation each of the two antennas 38, 40 is advantageously used to transmit on half of the frequency channels used by the sector and to receive on all of the frequency channels used by the sector. Each antenna 38, 40 is connected to a respective frequency-selective duplexor 52, 54, which isolates the respective receivers (not shown) from the transmit signals. In a particular embodiment, the splitters 56, 58 are preceded by respective first and second low-noise receive signal preamplifiers (not shown). In an alternative embodiment, the splitters 56, 58 are followed by respective first and second low-noise receive signal preamplifiers (not shown).

In a specific embodiment, the duplexor and the signal combiner may be integrated into a single device, as shown in FIG. 6. In the embodiment of FIG. 6, a dual diversity reception and transmit signal combining system 60 employs integrated duplexor/combiners 62, 64. Integration of the combiner and the duplexor into a single device yields the advantage of reduced size. An additional advantage is lower insertion loss because the interconnection of a frequency-selective filter in the combiner and a redundant frequency-selective filter in the transmit signal path of the duplexor is avoided.

In the embodiment of FIG. 6, a dual diversity reception and transmit signal combining system 50 advantageously includes four frequency channels having center frequencies f1, f2, f3, and f4. The frequency channels are coupled to a transmit signal processing path of the base station, as described in connection with the embodiment of FIG. 2. It is to be understood by those of skill in the art that any reasonable number of frequency channels could be used. Each frequency channel is input to a particular power amplifier 32, there being four power amplifiers 32 in the embodiment shown. The power amplifier 32 coupled to the f1 frequency channel is configured to send an output signal to a first transmit input port of a first integrated frequency-selective duplexor/combiner 62. The power amplifier 32 coupled to the f2 frequency channel is configured to send an output signal to a first transmit input port of a second integrated frequency-selective duplexor/combiner 64. The power amplifier 32 coupled to the f3 frequency channel is configured to send an output signal to a second transmit input port of the first integrated frequency-selective

duplexor/combiner 62. The power amplifier 32 coupled to the f4 frequency channel is configured to send an output signal to a second transmit input port of the second integrated frequency-selective duplexor/combiner 64. The first integrated frequency-selective duplexor/combiner 62 is connected to a first antenna 38. The second integrated frequency-selective duplexor/combiner 64 is connected to a second antenna 40. It is to be understood by those of skill in the art that while in the embodiment depicted there are two antennas in a sector of an exemplary CDMA base station, there could be any number of antennas in such a sector. The first integrated frequency-selective duplexor/combiner 62 is configured to send a signal from a receive output port to a first splitter 56, which is advantageously configured to send four output signals to, respectively, four receivers (not shown) for the four frequency channels f1, f2, f3, and f4. The second integrated frequency-selective duplexor/combiner 64 is configured to send a signal from a receive output port to a second splitter 58, which is advantageously configured to send four output signals to, respectively, the four receivers for the four frequency channels f1, f2, f3, and f4.

In a particular embodiment, the splitters 56, 58 are preceded by respective first and second low-noise receive signal preamplifiers (not shown). In an alternative embodiment, the splitters 56, 58 are followed by respective first and second low-noise receive signal preamplifiers (not shown).

As described with respect to the embodiment of FIG. 2, the power amplifiers 32 and the splitters 56, 58 are preferably conventional components. The integrated frequency-selective duplexor/combiners 62, 64 are also advantageously conventionally known components available off the shelf.

As those of skill in the art would readily appreciate, frequency channel spacings other than those herein described are possible. The frequency channels in, e.g., an IS-95A or J-STD-008 system do not need to be spaced 1.25 MHz apart; it is simply customary to do so. In a situation in which some frequency channels overlap, as shown graphically in FIG. 7, frequency-selective combining alone would not yield satisfactory results because there would be frequency components of one channel that could not be isolated from another channel by frequency selection alone. Yet the technique illustrated in FIG. 7, in which four frequency channels, each 1.25 MHz wide, are spaced 1.00 MHz apart (for clarity, only the dimensions of f1 and the spacing between f1 and f2 are depicted), can be useful when the total amount of frequency spectrum available is limited and nonoverlapping

frequency channels would waste some spectrum. Satisfactory results can be obtained using the system of FIG. 2.

Another overlapping-channel example is illustrated in FIG. 8. In this example spread spectrum signals of two different bandwidths are used. Thus, two spread spectrum signals of different bandwidths are being transmitted on the same center frequency, frequency f1. Using the system of FIG. 2, the wide f1 signal and the f3 signal could be combined and then presented to the first antenna 38, while the narrow f1 signal and the f2 signal are combined and then presented to the second antenna 40.

In the embodiments described herein, the isolation between the first and second antennas can be a result of the physical spacing between the antennas or can be provided by polarization of the antennas. If the isolation is provided by polarization, the two antennas could advantageously be replaced by one antenna with two feeds, one for a first polarization and one for a second polarization, where the first and second polarizations are orthogonal or nearly orthogonal. Several different combinations of orthogonal polarizations are possible, such as, e.g., {horizontal, vertical}, {linear tilted 45 degrees left of vertical, linear tilted 45 degrees right of vertical}, and {left hand circular, right hand circular}. Diversity reception using two receive antennas of different polarizations is known in the art.

Preferred embodiments of the present invention have thus been shown and described. It would be apparent to one of ordinary skill in the art, however, that numerous alterations may be made to the embodiments herein disclosed without departing from the spirit or scope of the invention. Therefore, the present invention is not to be limited except in accordance with the following claims.

What is Claimed is:

CLAIMS

1. A sector of a cellular base station in a CDMA system, comprising:

a plurality of antennas each used to transmit a respective set of frequency channels; and

a plurality of signal combiners each coupled on a one-to-one basis to a respective one of the plurality of antennas, each one of the plurality of signal combiners being coupled to a respective set of frequency channels, the sets of frequency channels being selected such that no two frequency channels in any one set are adjacent.

2. The sector of claim 1, wherein at least one of the frequency channels transmitted is a spread spectrum signal.

3. The sector of claim 1, wherein at least one of the frequency channels transmitted is a signal that complies with the TIA IS-95A standard.

4. The sector of claim 1, wherein at least one of the frequency channels transmitted is a signal that complies with the ANSI J-STD-008 standard.

5. The sector of claim 1, wherein at least one of the plurality of antennas is used for both transmission and reception.

6. A base station in a CDMA cellular telephone system, comprising at least one sector including a plurality of signal combiners each coupled to an antenna, each one of the plurality of signal combiners being coupled to a respective set of frequency channels, the sets of frequency channels being selected such that no two frequency channels in any one set are adjacent.

7. A sector of a cellular base station in a CDMA system, comprising:

means for transmitting a plurality of sets of frequency channels; and

means for combining individual frequency channels into respective sets of the plurality of sets of frequency channels such that no two individual frequency channels within any one set are adjacent, the means for combining being coupled to the means for transmitting.

8. The sector of claim 7, wherein at least one of the frequency channels transmitted is a spread spectrum signal.

9. The sector of claim 7, wherein at least one of the frequency channels transmitted is a signal that complies with the TIA IS-95A standard.

10. The sector of claim 7, wherein at least one of the frequency channels transmitted is a signal that complies with the ANSI J-STD-008 standard.

11. In a CDMA cellular telephone system, a method of signal transmission, comprising the steps of:

combining individual frequency channels into sets of frequency channels such that no two individual frequency channels in any one set are adjacent; and

transmitting the sets of frequency channels

12. The method of claim 11, wherein at least one of the frequency channels transmitted is a spread spectrum signal.

13. The method of claim 11, wherein at least one of the frequency channels transmitted is a signal that complies with the TIA IS-95A standard.

14. The method of claim 11, wherein at least one of the frequency channels transmitted is a signal that complies with the ANSI J-STD-008 standard

15. A sector of a cellular base station in a CDMA system, comprising:

a plurality of signal combiners each being coupled to a different set of frequency channels wherein no two frequency channels in any one set are adjacent;

a plurality of duplexors coupled on a one-to-one basis to respective ones of the plurality of signal combiners, each one of the plurality of duplexors being coupled to a respective one of the plurality of signal combiners;

a plurality of antennas each being coupled to a respective one of the plurality of duplexors; and

a plurality of splitters coupled on a one-to-one basis to respective ones of the plurality of duplexors, each one of the plurality of splitters being coupled to a respective one of the plurality of duplexors.

16. The sector of claim 15, wherein at least one of the frequency channels transmitted is a spread spectrum signal.

17. The sector of claim 15, wherein at least one of the frequency channels transmitted is a signal that complies with the TIA IS-95A standard.

18. The sector of claim 15, wherein at least one of the frequency channels transmitted is a signal that complies with the ANSI J-STD-008 standard.

19. A sector of a cellular base station in a CDMA system, comprising:

a plurality of integrated duplexor/combiners each being coupled to a different set of frequency channels wherein no two frequency channels in any one set are adjacent;

a plurality of antennas each being coupled to a respective one of the plurality of integrated duplexor/combiners; and

a plurality of splitters coupled on a one-to-one basis to respective ones of the plurality of integrated duplexor/combiners, each one of the plurality of splitters being coupled to a respective one of the plurality of integrated duplexor/combiners.

20. The sector of claim 19, wherein at least one of the frequency channels transmitted is a spread spectrum signal.

21. The sector of claim 19, wherein at least one of the frequency channels transmitted is a signal that complies with the TIA IS-95A standard.

22. The sector of claim 19, wherein at least one of the frequency channels transmitted is a signal that complies with the ANSI J-STD-008 standard.

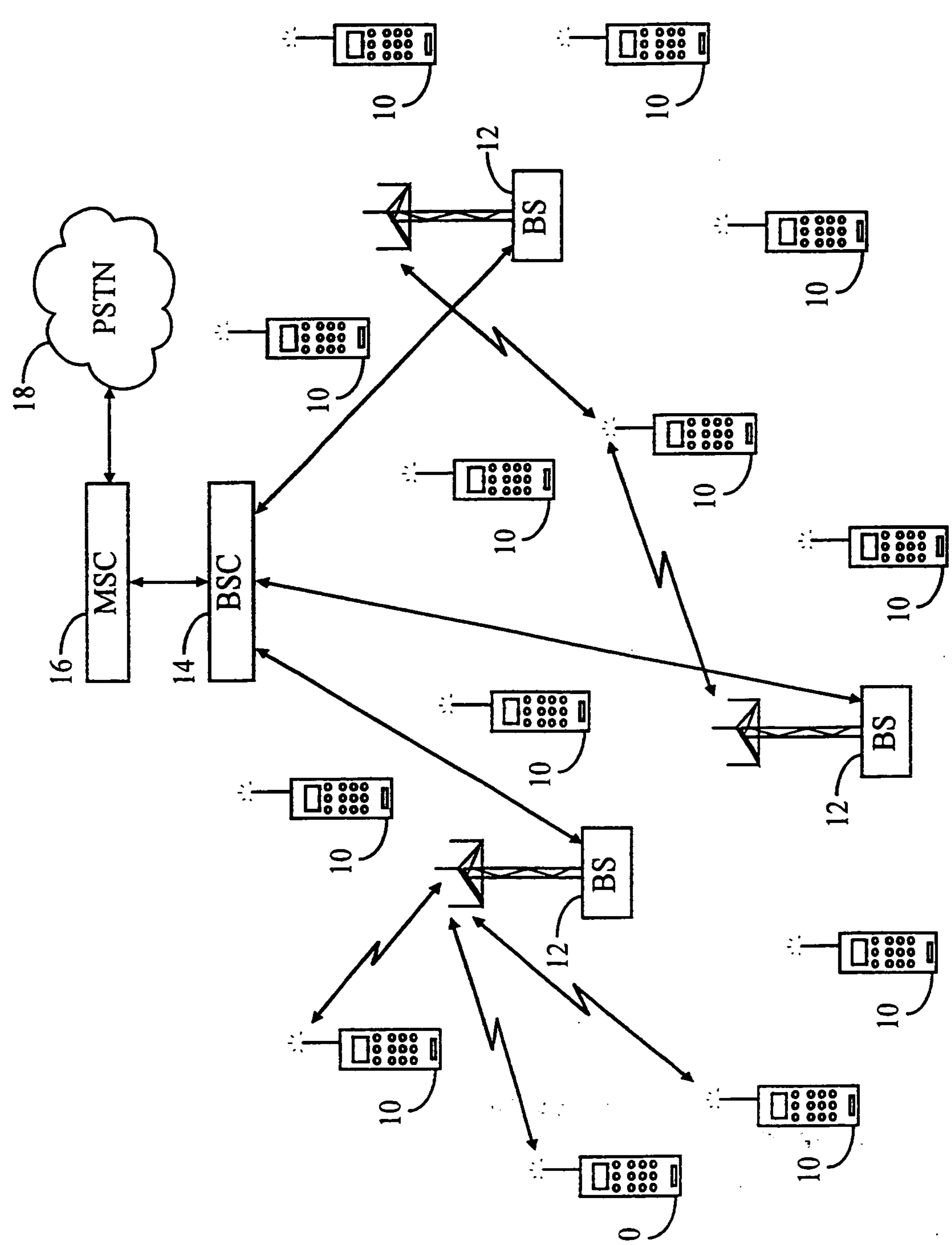

FIG. 1

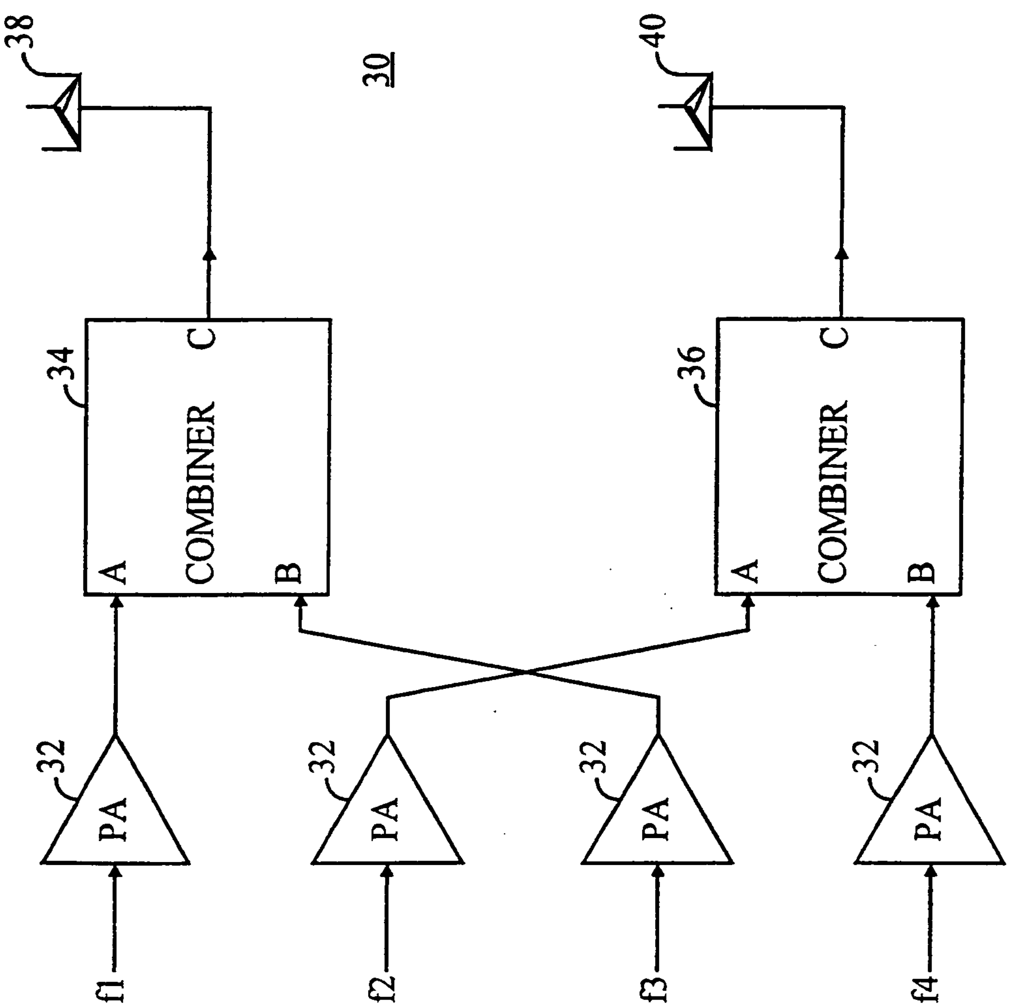
38
30
40
34
COMBINER
A
B
C
36
COMBINER
A
B
C
32
PA
32
PA
32
PA
32
PA
f1
f2
f3
f4

FIG. 2

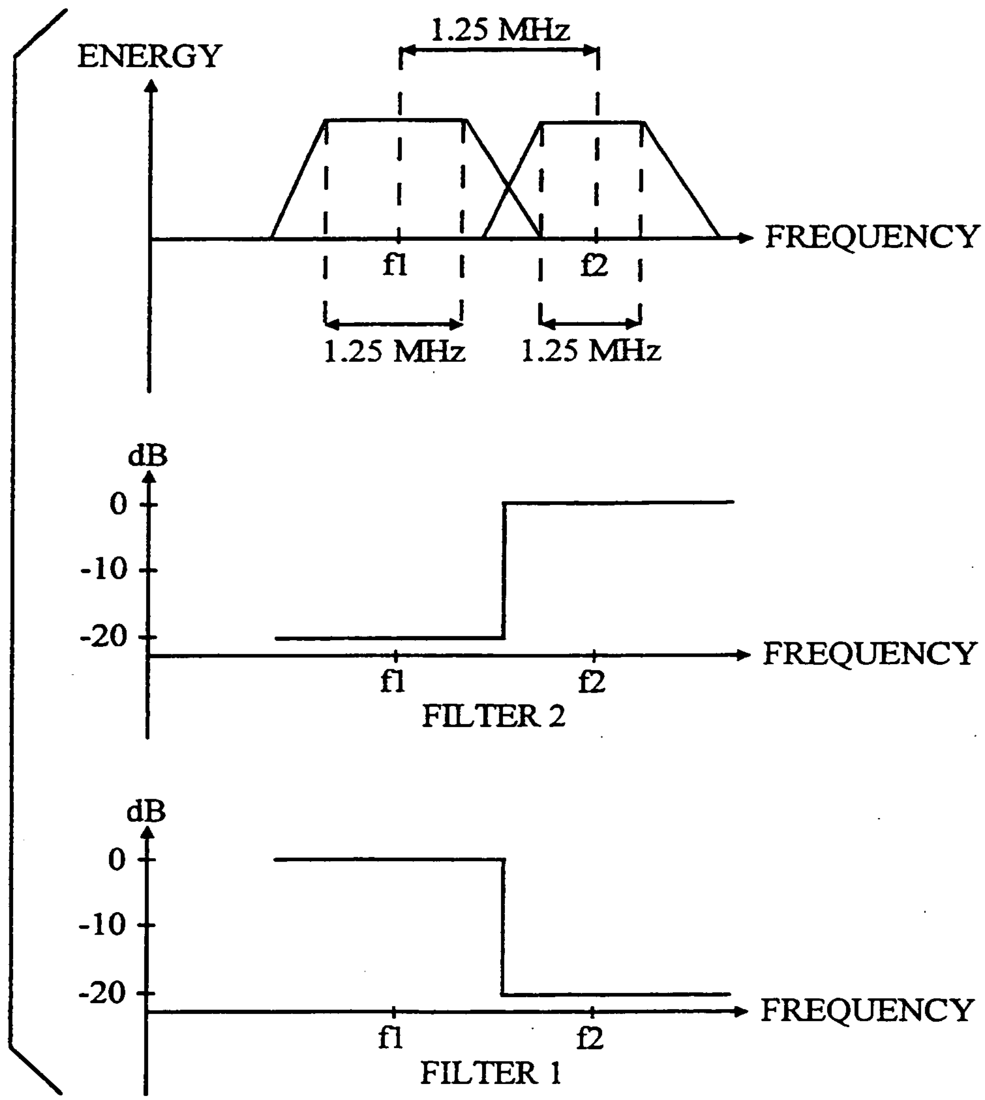
ENERGY
1.25 MHz
FREQUENCY
f1
f2
1.25 MHz
1.25 MHz
dB
0
-10
-20
FREQUENCY
f1
f2
FILTER 2
dB
0
-10
-20
FREQUENCY
f1
f2
FILTER 1

FIG. 3

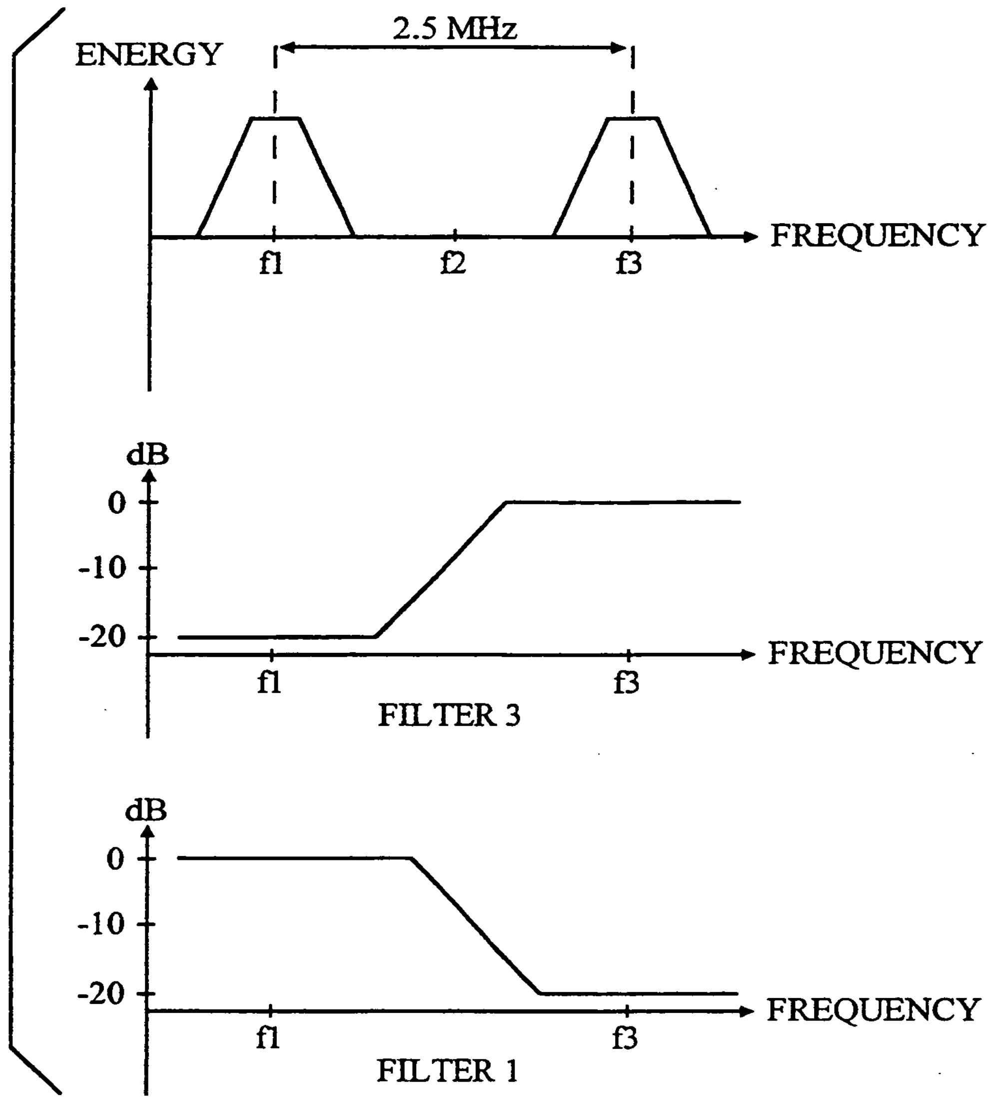
2.5 MHz
ENERGY
FREQUENCY
f1
f2
f3
dB
0
-10
-20
FREQUENCY
f1
f3
FILTER 3
dB
0
-10
-20
FREQUENCY
f1
f3
FILTER 1

FIG. 4

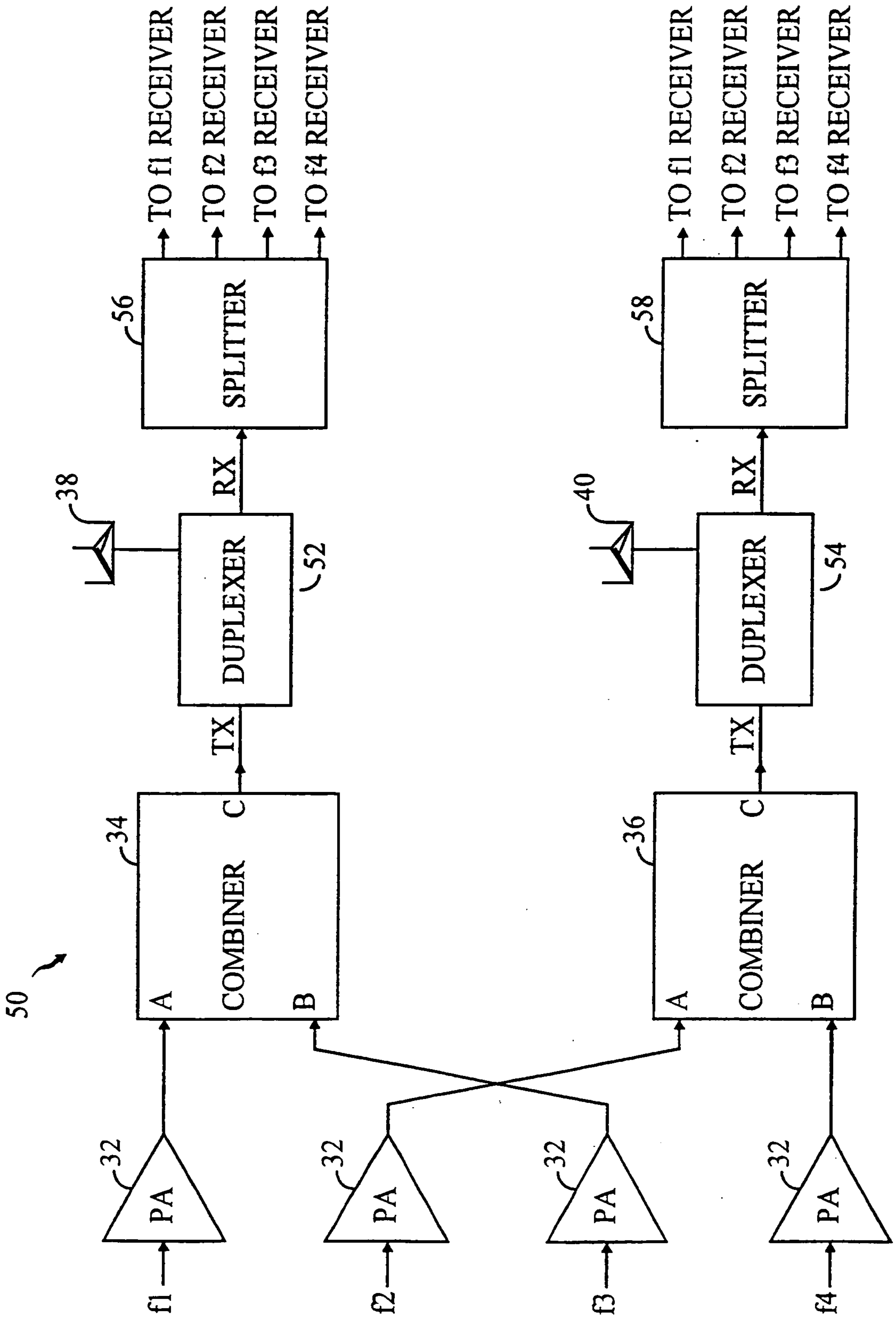
50
f1
f2
f3
f4
PA
32
COMBINER
A
B
C
34
36
TX
RX
DUPLEXER
52
54
38
40
SPLITTER
56
58
TO f1 RECEIVER
TO f2 RECEIVER
TO f3 RECEIVER
TO f4 RECEIVER

FIG. 5

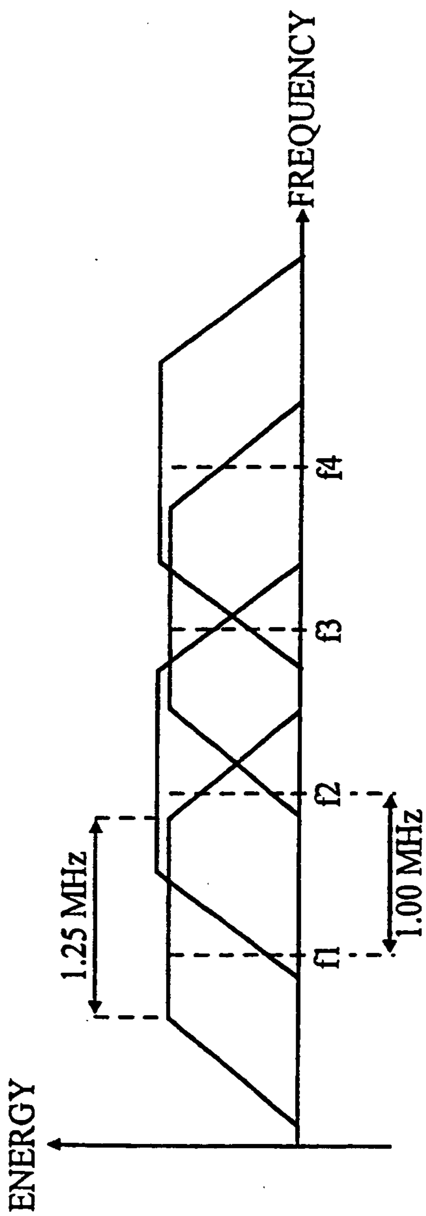
ENERGY
FREQUENCY
1.25 MHz
1.00 MHz
f1
f2
f3
f4

FIG. 7

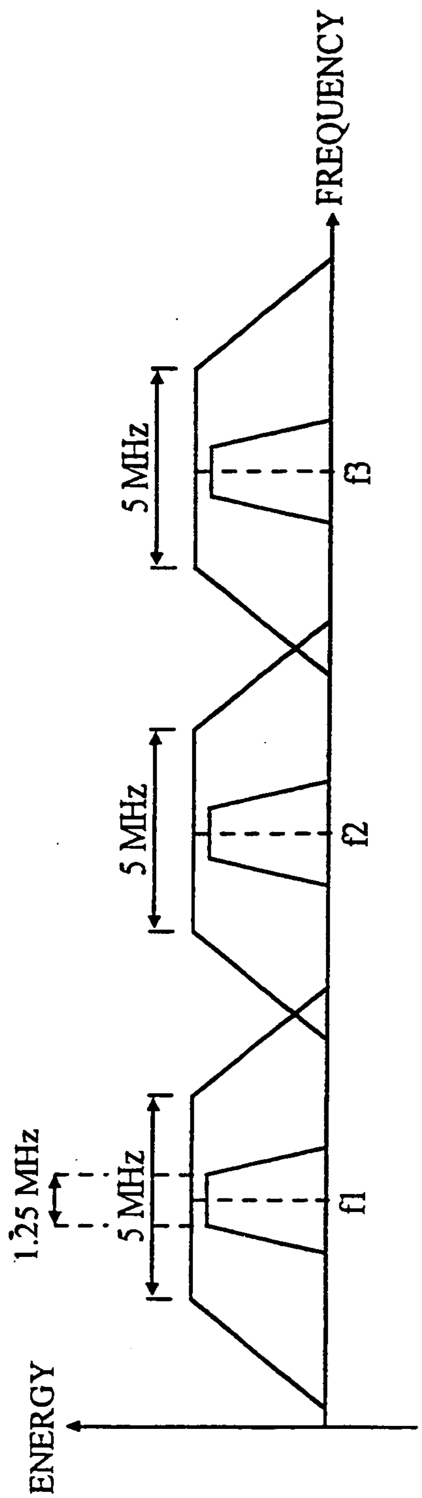
ENERGY
FREQUENCY
1.25 MHz
5 MHz
5 MHz
5 MHz
5 MHz
f1
f2
f3

FIG. 8

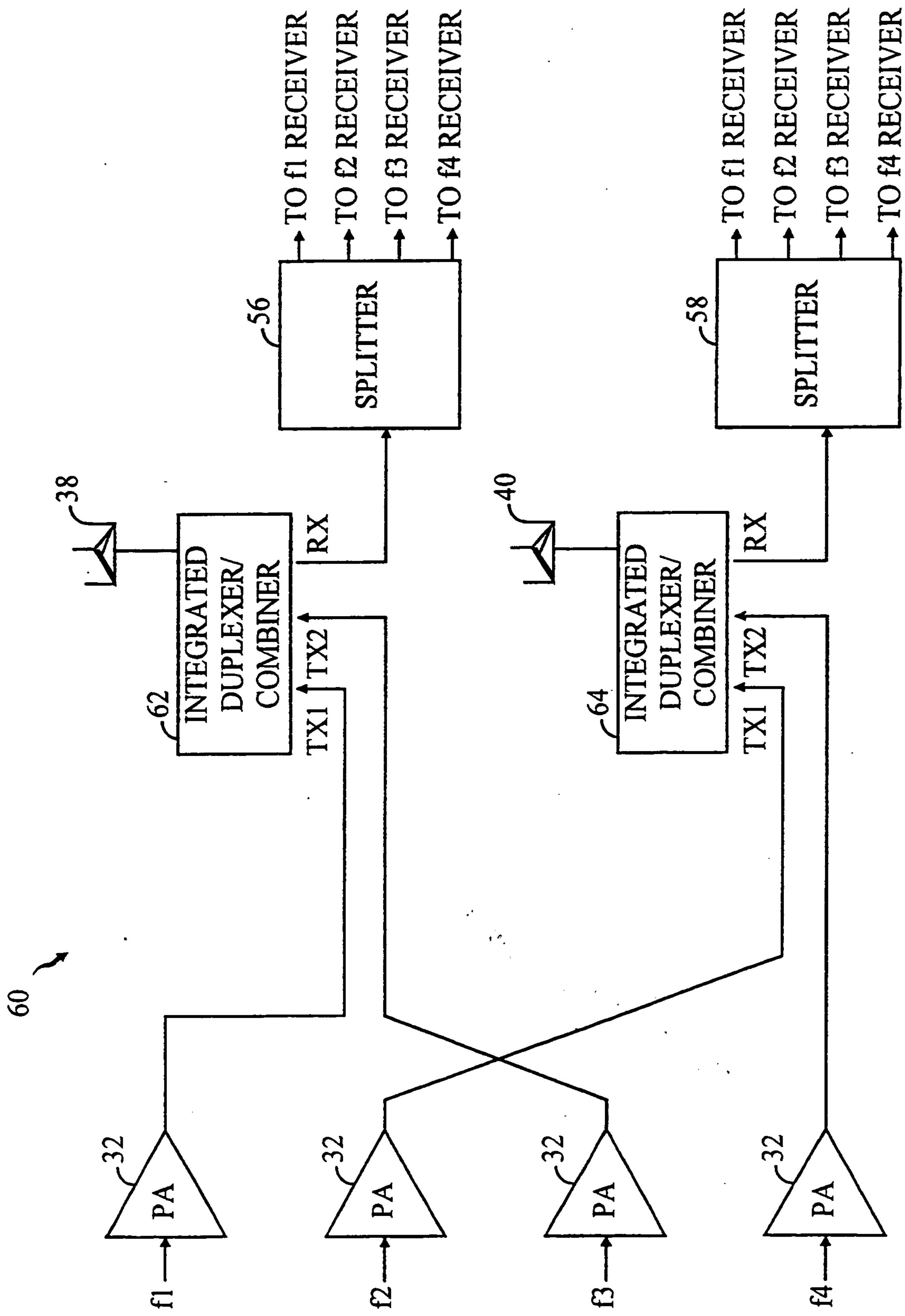
60
f1
f2
f3
f4
PA
PA
PA
PA
32
32
32
32
62
INTEGRATED DUPLEXER/ COMBINER
TX1
TX2
RX
38
64
INTEGRATED DUPLEXER/ COMBINER
TX1
TX2
RX
40
56
SPLITTER
58
SPLITTER
TO f1 RECEIVER
TO f2 RECEIVER
TO f3 RECEIVER
TO f4 RECEIVER
TO f1 RECEIVER
TO f2 RECEIVER
TO f3 RECEIVER
TO f4 RECEIVER

FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/07105

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B7/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 0 622 910 A (ERICSSON GE MOBILE COMMUNICAT) 2 November 1994 see page 2, line 5 - line 8 see page 3, line 7 - line 17 see page 5, line 40 - page 6, line 3; figure 2 see claims 1-3,8,9,14,15 ---	1-4,6-14 5,15-22
Y	US 5 483 667 A (FARUQUE SALEH M) 9 January 1996 see column 1, line 55 - column 2, line 20 see column 3, line 28 - line 61; figure 5 --- -/--	5,15-22

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 July 1999	14/07/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ó Donnabháin, E

1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/07105

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	TIEDEMANN E G JR: "An overview of the CDMA PCS system" PROFESSIONAL PROGRAM PROCEEDINGS. ELECTRO '96 (CAT. NO.96CH35926), PROFESSIONAL PROGRAM PROCEEDINGS. ELECTRO '96, SOMERSET, NJ, USA, 30 APRIL-2 MAY 1996, pages 331-335, XP002107895 ISBN 0-7803-3271-7, 1996, New York, NY, USA, IEEE, USA see abstract see page 332, line 1 - page 333, column 1, line 8	3,4,9, 10,13, 14,17, 18,21,22
A	EP 0 797 369 A (NIPPON TELEGRAPH & TELEPHONE) 24 September 1997 see abstract	1-22

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 99/07105

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